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GUIDELINES FOR SPECIFICATION AND PROCUREMENT OF MEASUREMENT INSTRUMENTATION

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U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, Secretary
Sidney Harman, Under Secretary
Jordan J. Baruch, Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

FOREWORD

This report presents guidelines for the procurement of measurement instrumentation by organizations in the developing countries. It is based on a two-week experimental educational course presented in the fall of 1976 by the Denver Research Institute, under contract from the U.S. National Bureau of Standards with funding from the U.S. Agency for International Development. A number of reviewers have contributed valuable suggestions, especially Dr. L. Yardley Beers of NBS.

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LIST OF CHECKLISTS

I. INTRODUCTION

Instrumentation is necessary in almost every measurement process. Measurement is essential in modern science, technology, industry, and commerce. For instance, it is often stated that about 25 percent of the equipment cost of typical modern industrial plants is spent on measurement instrumentation. Measurements are needed in industry for process and quality control, for environmental control and protection, and for protection of workers from dangers in their work-places.

The accelerating pace of the advancement of science and technology during the past several decades is well known. Measurement instrumentation has experienced a similar advancement. One result has been an increasing abundance of measuring instruments specialized for particular tasks. Another result is that specification and selection of an optimum instrument are becoming increasingly complex tasks.

Recent trends in measurement instrumentation include the incorporation of new materials, the use of an increasing variety of physical phenomena, and exploitation of advances in solid-state electronics, and computer science and technology. Automation by built-in mini- and micro-computers can be particularly valuable for the developing nations. Such automation allows measurements to be made more rapidly, more reliably, without auxiliary computations or corrections, by relatively unskilled personnel, than with non-automated equipment. As a result, the developing nations can obtain highly precise and reliable measurements by use of relatively untrained people. Highly skilled technicians and professionals can be released for other urgent assignments.

This report provides guidelines to ease the problems of the specification and procurement of measurement instrumentation by establishments in the developing nations. With suitable changes in the technical terms these guidelines can be used for specification and procurement of other scientific or technical equipment.

The report is built around a series of checklists. The checklists are intended to list everything that is needed in a major procurement action, in a logical or chronological sequence. They can be of value even to individuals highly experienced in the procurement process.

The narrative discussions accompanying the checklists are intended to provide explanatory material and advice useful to individuals not highly experienced in procurement actions. While experienced individuals will find much in these narrative sections that is obvious to them, they may also find them useful as means of insuring that they have not overlooked steps or considerations that would be useful in a particular procurement situation. No attempt has been made to discuss in detail every item in each checklist. Those items that appear to be completely obvious and self-explanatory are only listed.

Checklist I outlines the entire procurement process. The subsequent sections discuss first the respective responsibilities of the technical and purchasing staffs and then, secondly, the details of the substantive steps in the procurement action.

II. PROCUREMENT RESPONSIBILITIES

The procurement of measurement instrumentation usually involves two different groups in any establishment, the technical staff and the purchasing staff. Both report to a common top management and administrative budget authority.

A. Technical Staff

The technical staff of the buying organization is responsible for the use of the equipment to be bought. These technical people have the ultimate responsibility for the adequacy of procurement decisions. For this reason we strongly recommend against a frequent practice in developing countries of seeking external advice on and pursuing the procurement of technical facilities, with the intention of subsequently hiring the technical staff to operate them. This practice necessarily entails risks of expensive mistakes. It is strongly recommended that the technical staff in the buying organization be available throughout the purchasing cycle. It must have the final responsibility and authority for several aspects of the buying process.

The technical staff must prepare the formal procurement proposals that are presented to higher managerial or governmental authorities for approval. These proposals must be technically sound. They must also be presented in language and with justifications that are convincing to such people as governmental administrators who may be politicians or financial experts with little technical background. To be convincing to such people, a proposal must clearly establish the benefits that will occur as the result of the proposed procurement and must clearly define the adverse consequences (loss of benefits or real negative effects) if the procurement is not approved. Technical matters must be discussed in language a non-technical person can understand.

The technical staff must have the final responsibility for the technical acceptability of the equipment to be bought. The purchasing staff may request and obtain many compromises during the procurement process, but the technical staff must have the ultimate say about whether any proposed compromise is technically acceptable.

CHECKLIST I. THE PROCUREMENT PROCESS (AND RESPONSIBILITIES*)

A. Identify motivations and specific purposes of proposed procurement (T).

B. Conduct preliminary survey of available equipment (T,p).

C. Write basic functional specifications for desired equipment (T).

D. Prepare proposal document justifying proposed procurement (T).

E. Obtain basic budgetary approval (T).

F. Conduct search for potential suppliers and candidate instruments, including in-house fabrication possibilities (T,P).

G. Evaluate potential suppliers and set up bid list (T,P).

H. Develop detailed specifications (see Checklist IV) (T,p).

J. Identify conditions of sale (see Checklist V) (t,P).

K. Issue Requests for Quotation (RFQ's) (see Checklist VI) (P).

L. Evaluate bids (quotations) (T,P).

M. Negotiate with suppliers or recycle through steps G-L, as needed, until satisfactory bids are obtained (t,P).

N. Obtain formal approval for procurement (T,P).

P. Issue purchase and/or in-house fabrication orders (P).

Q. Follow-up on purchase or in-house fabrication orders (T,P).

R. Monitor delivery and installation of equipment and training of operators (T,P).

S. Issue notice of acceptance of equipment and authorization for payment (t,P).

T. Maintain continuing good relationships with suppliers (T).

*T = major responsibility for technical staff
t = advisory or supportive responsibility for technical staff
P = major responsibility for purchasing staff
p = advisory or supportive responsibility for purchasing staff

B. Purchasing Staff

The purchasing staff is responsible for all non-technical aspects of the procurement process and for all non-technical communications with the suppliers, actual or potential. It is also responsible for assuring that all technical aspects handled by the technical staff are procedurally complete and sound. An experienced purchasing staff will be able to judge when unsound decisions are being made by the technical staff, and has a duty to advise the appropriate technical managers or top management when it sees a danger that technically unsound procurements are about to be made.

In summary, the purchasing staff is responsible to the establishment for the total soundness, technical and non-technical, of the proposed procurement. While purchasing officers cannot override the technical judgment of the technical staff, they can and must, when the occasion warrants, bring concerns about technical judgments to the attention of higher management for resolution.

C. Higher Management and Budgetary Authorities

Higher management and budgetary authorities must establish the framework within which the procurement actions take place. They must establish the requirements for content or format of procurement proposals. They must establish the procedural safeguards surrounding the actual purchasing process. Above all, they must be able and willing to receive and evaluate procurement proposals. These proposals must be placed into a larger context of organizational or national priorities, and decisions made among the various competing proposals. The reasons for adverse decisions should be communicated to the originators of the proposal. Favorable decisions must not be capriciously reversed. Later, during the actual procurement actions, these higher authorities must seek to resolve any conflicts that may arise between the technical and purchasing staffs in a manner that is supportive of both.

It is particularly important that the higher management and budgetary authorities in a developing nation be aware of the difficulties under which their technical and purchasing staffs may be laboring in obtaining adequate information for making sound buying decisions. It may well be advisable to defer some proposed procurements in order to release funds that will insure the soundness of other major procurements. Travel abroad to see equipment in actual use and to visit the plants of instrumentation manufacturers may be an exceedingly wise investment.

Situations sometimes arise in which higher management or budgetary authorities demand of the technical staff commitment of substantial funds within very short periods of time. When such possibilities exist, it is imperative that higher authorities give significant advance warning to the technical staff and that the technical staff respond rapidly to the warning. Unless the technical staff is prepared for rapid decisions once the funding becomes available, it will certainly be fiscally wisest to lose the available money rather than make hasty decisions that can have long term negative effects.

The following statements by William A. Wildhack, Associate Director of the U.S. National Bureau of Standards, retired, are included here to support the present authors' appeal to higher management and budgetary authorities for understanding and support of their technical staff members as they struggle with the problems of procurement from foreign countries. The comments are part of Mr. Wildhack's contribution to the report of the 1977 NBS/AID Workshop on Standardization and Measurement Services.

"Shortly after World War II, I was serving as Chairman of a Committee on Instrumentation in the National Research Council (International Relations Division). Our concern was to help educational and scientific laboratories abroad to replace, refurbish, or modernize the research facilities...

"The program was of great value in both education and research, but there were many problems for the person in the laboratory abroad struggling with long distance procurement. First, he had only catalog descriptions--sometimes out of date--and the manufacturers' data and claims on which to base his choice. As all of you are well aware, there are reviewing officials, procurement officials, custom officials, budget officials, etc., etc. between the laboratory technologist and the delivery of the instrument ordered. Without his knowledge, they may 'edit' his specifications, add the infamous 'or equivalent' [note: the present authors regard this as 'infamous' only when added without the technologist's knowledge] to his specifications of manufacturer or model, chop off the last ten items of his list of requests--or pigeon-hole all of them for a few months. Any of these disasters may jolt the technologist as much as the vagaries of overseas shipment may jolt the sensitive instruments...

"To keep NBS screening from becoming another hurdle for the foreign laboratories, I soon proposed that we should serve as consultant to them, rather than as a critic of their requests... But the problems of getting instruments of adequate performance, with compatible accessories, is not simple, even in the high-technology countries, and the problems increase exponentially with geographic distance and with language specification uncertainties."

III. THE PROCUREMENT PROCESS

A total or ideal procurement action is described here. For simple, routine, and inexpensive items, some of the steps of this ideal process will usually be handled so easily that there will be little or no consciousness of them as distinct steps. For major procurements, any step may require much time and effort. The authors acknowledge that purchasing procedures may often be much simpler than those discussed or implied in this report, and sincerely hope that this will be so for most of the users of this document.

A. Motivations and Purposes of Procurement

Possible motivating factors for procurement of new measurement instrumentation are given in Checklist II. The needs and opportunities to which the proposed procurement relates and the method by which the equipment will be utilized need to be clearly defined. It is important to know how the proposed new capabilities will fit into the establishment's long range plans. Specific functions, purposes, or goals that will be served, need to be defined for the new equipment. A definite connection must be established between the goals that can be achieved and the specific needs that justify the proposed purchase.

B. Preliminary Survey of Available Equipment

Any procurement of measurement instrumentation will be substantially limited to selections among commercially available instruments. Equipment built to meet custom specifications usually cannot depart too far from that routinely available, if it is not to be extremely expensive. Similarly, equipment custom-built in-house will usually be similar to commercially available designs and will employ many commercially available components or subassemblies. Therefore, it is important at an early stage of the procurement action to make a preliminary survey of the commercially available measurement instrumentation.

In the more developed countries, surveying the available measurement instrumentation means consulting the literature and current users of relevant equipment. Advertisements in the scientific and trade literature can be quite useful sources of information. Catalog files may be available in the establishment's purchasing department, or in those of other establishments in the area. Individual scientists and engineers often maintain very useful personal catalog files, and inquiry among colleagues may lead to location of such files. Local instrumentation vendors and sales representatives are sources of descriptive sales literature. Current instrumentation users can be identified by telephone calls to the local vendors or representatives, or to colleagues likely to be working in the field. Useful information can be obtained from these users by telephone calls, or by simple visits.

CHECKLIST II. MOTIVATIONS FOR PROCUREMENT

A. Implementation of an authorized new program.

B. Exploitation of new measurement capabilities made possible by newly available instrumentation.

C. Response to new legal requirements, for instance in pollution control.

D. Response to competitive pressures, especially in industry, for instance in quality control.

E. Replacement of obsolete or worn-out equipment.

F. Current availability of funds.

If the country has national standards or metrology or instrumentation laboratories, any of those can be a very useful source of information. Attendance at trade shows and scientific conferences can also provide opportunities to gather information from instrumentation vendors and users.

In the less-developed countries, or for very unusual or expensive equipment anywhere, it is far less easy to obtain the needed information. Local sales representatives or vendors may be lacking. There may be no known users in the local area. Relevant trade literature may not be available. Telephone or cable inquiries may be expensive and unrewarding. Mail inquiries may be very slow and unreliable. It may not be at all obvious where to begin, or how to press forward on a reasonable time scale commensurate with the need for the new equipment.

Three places to begin within a less-developed country are these: (1) Inquiries to any instrumentation vendors or sales representatives that do exist within the country or region. (2) Inquiries to colleagues who may have already had similar problems, and can at least provide advice on specific ways to proceed. (3) Inquiries to the embassies or consulates of the major instrumentation-supplying industrial countries, e.g., the United States, Japan, the United Kingdom, Germany, France, and Switzerland. U.S. embassies, for instance, will channel inquiries to U.S. manufacturers and have available the Thomas' Register of American Manufacturers, an extremely comprehensive guide to the products of U.S. industry. While this is not a complete guide to the manufacturers of instrumentation for measurement, testing, and quality control purposes, it is an excellent beginning.

In the field of scientific instrumentation, the American Association for the Advancement of Science publishes an annual Guide to Scientific Instruments, as a special issue of its journal Science. The Guide issue can be purchased by writing to the American Association for the Advancement of Science, Guide to Scientific Instruments, 1515 Massachusetts Avenue NW, Washington, D.C. 20005 USA.

If a measurement involves an electrical output or electrical or electronic equipment, relevant instrumentation is likely to be listed in the Electronic Engineers Master Catalog. This is published by United Technical Publications, Inc., 645 Stewart Ave., Garden City, NY 11530 USA.

Other relevant buyer's guides have been published by two trade magazines: Instruments and Control Systems, Chilton Company, Chilton Way, Radnor, PA 19089 USA; and Quality, the Magazine of Product Assurance, which can be ordered within the USA, Canada and Mexico from Hitchcock Publishing Co, Hitchcock Building, Wheaton, IL 60187 and from outside the USA through Reliable Information Publishing Co., PO Box 7570, 5242 Birr, Switzerland.

The buyer's guides listed above are in our judgment the most useful ones for present purposes produced in the United States. Many others exist. Inquiries to local embassies, consulates, or trade missions should serve to identify such guides published in other countries.

For major purchases of complex equipment, simply studying the available literature is not adequate. It is necessary to see the different available instruments in use and to talk with their users. The investment of the time and travel cost to send a senior technical staff member to a location where this can be done is often imperative. It is often very valuable to include attendance at scientific conferences and trade shows in this travel. The authors of this report cannot stress too strongly to those that must approve such travel its importance, either at this stage of the procurement process or in stage F below.

C. Functional Specifications

After the specific purposes or goals of the proposed equipment purchase have been defined and a preliminary survey of the available instrumentation has been conducted, basic functional performance specifications can be established for the equipment to be procured. These specifications should be "ideal" in nature. They should outline in general terms exactly what the organization wants if it can find or build it, and can afford it. They also should outline the alternatives or compromises that will be acceptable if it does not prove possible to get exactly the equipment wanted. Details to be considered while developing the functional specifications are presented in Checklist IV, Specification of a measuring instrument (see p. 15).

D. Procurement Justification Proposal Document

At times, this document may be a mere formality. At other times, it is crucially important. It must be both technically sound and comprehensible to the non-technical administrator.

E. Basic Budgetary Approval

There is no point in proceeding further with the proposed procurement unless at least tentative budgetary approval is achieved at this step of the process.

F. Search for Potential Suppliers and Candidate Instruments

Once a set of ideal functional performance specifications exists and basic budgetary approval has been granted, it is necessary to identify potential suppliers and candidate instruments that might acceptably match the specifications. A search should be made of the trade literature: catalogs, trade journals, and buyer's guides. Users of relevant instrumentation should be asked their suggestions and opinions. Attendance at trade shows or scientific meetings may provide useful contacts. Visits by sales representative may be solicited. The purchasing agents in the buying establishment may be very valuable sources of advice and assistance. They should be asked to contact the potential suppliers identified during this step, to obtain additional catalogs, brochures, instruction manuals, instrument schematics, and other relevant literature.

In-house fabrication of all or part of the needed instrumentation should be considered. In the U.S. in-house fabrication is often thought to cost more (as a rule) than buying from an external supplier. Many specialized measurement instruments, such as electron microscopes, can scarcely ever be built in-house. At times, however, part or all of the desired instrumentation can advantageously be built within the organization. Sometimes internal fabrication is the only way to get the equipment desired. Advantages of in-house fabrication may include an ability to control the design and construction of the equipment to get exactly the results wanted, a greater ease of maintenance of equipment built in-house, and by-product factors such as the value of the experience gained while designing and fabricating the apparatus. In-house fabrication in an establishment in a developing country may also support the establishment or expansion of a domestic instrumentation industry.

G. Evaluation of Potential Suppliers

Both the technical and business qualifications and reputations of the potential suppliers need to be assessed. Potential in-house suppliers should be included. The technical and procurement experts in the buying establishment must work closely with each other. The final list of suppliers who will be asked to bid on the procurement action must be a joint recommendation of the two groups of experts. Checklist III tabulates actions to be taken and factors to be considered during this process.

At the conclusion of this phase of the procurement process, preliminary price/performance analyses can be made, and the list of potential suppliers narrowed down to a select few that will be asked to bid on the procurement. A report and purchase request should be submitted to the establishment's managerial and fiscal authorities for at least tentative budgetary approval of a reasonably firm estimated cost. This approval should be obtained before any significant amount of additional effort is expended on this procurement action.

CHECKLIST III. EVALUATION OF POTENTIAL SUPPLIERS AND INSTRUMENTS

A. Study of suppliers' product literature.

B. Reputation with existing instrument users, (e.g., as determined during conversations at scientific conferences).

C. Demonstrations or inspection of instruments in actual use.

D. Technical and business capabilities of local sales and service agents, and adequacy of facilities, with respect to such factors as:
   1. Installation support
   2. Operator training
   3. Repair and maintenance support
   4. Spare parts and operating supplies service

E. Visits to suppliers' facilities, by both technical and purchasing experts.
   1. Local
   2. Home office and factory, when feasible.

F. Assessment of strengths and weaknesses of candidate equipment by discussions with suppliers' technical service and maintenance and repair staffs.

G. Specific factors in instrument assessment:
   1. Ability to generate the measurement data desired
   2. Cost
   3. Degree of operator skill required
   4. Instrument reliability and probable downtime
   5. Ease of calibration, repair and maintenance
   6. Ready availability of routine operating supplies and spare parts
   7. Overall instrument durability and expected lifetime
   8. Adaptability to local conditions, such as 50 cycle power supplies or high humidities
   9. Need for auxiliary equipment or supporting facilities
   10. Space and utility services required
   11. Ease of installation
   12. Probable delivery time

H. Development of Detailed Specifications

The ideal functional specifications often must be modified to be consistent with the actual capabilities of potential suppliers or with realistic budget figures. Also, the functional generalities must be reduced to specific numbers before it will be possible to obtain firm price and delivery quotations. The resulting detailed description of the product to be purchased can range from simple verbal statements over a telephone to elaborately processed documents contained in several bound volumes. Generally, the detailed product specifications are adequately provided by a rather modest document.

The importance of providing complete and comprehensive specifications cannot be overemphasized. This is especially true for procurements by establishments in developing countries. These establishments may have requirements that are not normally specified in the standard product descriptions published by foreign instrumentation manufacturers. The presence of unavoidable communication barriers, such as distance, language, and differences in customs, makes it especially desirable to avoid all possible sources of misunderstanding between buyer and seller. Inadequate specifications can lead to extensive lost time, while the supplier checks to determine the missing data. Changes in specification while an instrument is being manufactured will almost always involve both lost time and money. An inadequately specified instrument may require extensive modifications after delivery and may never perform satisfactorily.

For most instrumentation purchases cost and service considerations require buying essentially standard equipment. In these cases, the detailed specifications will be based directly on the manufacturers' published specification sheets. Such specification sheets may be inserted directly into the buyer's specification document, or they may be referenced, or they may be used as sources of data contained in the document. Additional specifications may be noted as modifications of, or additions to, those published by the manufacturers. Standard clauses can be inserted or referenced. When several substantially equivalent pieces of apparatus from different suppliers are being considered, the specification document may use such language as "equal to or exceeding" or "providing performance substantially equivalent to or exceeding that characteristic of," followed by a clear statement of a numerical parameter which represents the minimum performance of any of these instruments or by identification of the least acceptable instrument in the group.

However, a buying organization should never assume that a manufacturer's specifications cover every factor of importance, or that these factors are adequately specified even when covered. This is especially true when dealing with foreign suppliers not accustomed to the conditions in the buying country; and it is especially true with respect to claims for such factors as instrument precision and accuracy. The technical and procurement experts of the buying establishment must review very carefully all published specifications and request those clarifications, changes, or additions which are pertinent to the goals of the buying organization. The manufacturers should be consulted about any such modifications of their specifications, to determine their ability and willingness to deviate from the standard specifications, and to determine the probable cost and delivery time effects of the changes. Some desirable changes will be easy and inexpensive, others may be difficult and prohibitively costly.

Checklist IV outlines the details that must be defined when specifying an instrument for measurement, testing, or automatic control purposes. Because the items on the list are largely self-explanatory, comments will be restricted to the exceptions.

Specification of the auxiliary and interfering conditions (items A-4 and A-6) are closely related topics. The buyer must be careful to specify enough of the total circumstances under which an instrument will be used that the supplier delivers an appropriate piece of equipment. Emphasis should be on specification of performance requirements, not the actual details of construction, to provide flexibility to the vendors in how they choose to respond.

Specification of desired accuracy and precision capabilities (A-5) is a major source of confusion. Scientists themselves are often not very clear about what they mean by these terms. Instrument manufacturers are typically even less clear. Statements about instrument accuracy, precision and stability must be very carefully examined. Sometimes uncertainties about actual instrument capabilities can be resolved by asking a manufacturer to analyze a sample submitted by (and known to) the buyer. If they can be obtained, copies of statistical control charts for the instruments in actual use can provide very valuable information.

The controls and adjustments provided on the instrument deserve special attention (B-7). Some modifications may be very easy to make and quite useful. Attention should be directed to making the controls used during normal operation as simple and as accessible as possible.

Controls used for routine calibrations or adjustments by the operator (but not normal operation) should be accessible but protected so that they are not accidentally mis-set. Consideration should be given to specifying "locked-in" calibration adjustments. Experience in the United States indicates that greater uncertainties can be introduced by allowing an operator freedom to recalibrate certain instruments at will than exist due to the day-to-day and month-to-month variations caused by changes in instrument performance, with a fixed calibration adjustment. Controls and adjustments useful only for maintenance and repair purposes should be located so as to prevent access by the normal instrument operator. Non-standard test points and adjustments may be desirable, to ease maintenance and repair problems in the absence of a complete local service facility maintained by the manufacturer.

The subject of "built-in test" (F-2) involves a continuation of the thoughts of the previous paragraph. A recent trend in the U.S. is to build into an instrument a self-diagnosis capability. Then, when it misfunctions, it can be used to provide data for use in locating and repairing the fault. Establishments in developing nations should stress built-in test capabilities in the instruments they buy.

Spare parts (F-5) are a particular problem in the developing countries. This problem can be eased by specification of parts and components which are relatively easily available to the buying establishment. The use of metric threads and fasteners could be an example. Emphasis on purchase of equipment already in wide use locally is another approach. This may lead to requiring a manufacturer to supply auxiliary equipment made by another firm or to buying component units from several different suppliers. It may be possible to specify equipment in such a fashion that some key spare parts or operating supplies can readily be made within the establishment's own workshops. A prudent supply of spare parts and operating supplies (e.g., at least enough for two years) should be ordered along with the instrument. Manufacturers should be questioned about their ability and willingness to provide spare parts rapidly, on an emergency basis. The whole issue of spare parts and operating supplies should be a major consideration in the final choice of a supplier.

It is impossible to overstate the necessity of obtaining adequate instruction manuals and instrument drawings and schematics (F-6). Final payment should absolutely be refused until the manuals and schematics have been delivered. It is often very useful to obtain delivery of the manuals and schematics well in advance of the instrument itself, to aid in preparing for the arrival, installation and initial use of the instrument. It is important to keep instrument manuals and schematics physically with the instrument (F-7). Built-in compartments for doing so should be provided whenever possible.

CHECKLIST IV. SPECIFICATION OF A MEASURING INSTRUMENT

A. Purpose
   1. Generic name (e.g., spectrophotometer)
   2. Phenomena, materials, or objects to be measured
   3. Range of values or magnitudes to be measured
   4. Ranges of relevant auxiliary quantities (e.g., frequency)
   5. Accuracy and precision desired, with terms and conditions clearly defined
   6. Desired insensitivity to potential interfering phenomena
   7. Production rate or operating speed (e.g., sample processing time)

B. Implementation
   1. Physical principle
   2. Measuring or sensing technique
   3. Design approach
   4. Detailed design alternatives
   5. Construction materials
   6. Physical size and layout, for accessibility, etc.
   7. Controls and adjustments
   8. Built-in automation and data processing
   9. Mode of presentation of output data (e.g., strip chart)
   10. Processing required of output data to get useful information
   11. Color, finish, general appearance

C. Supporting facility requirements
   1. Electrical power and special power supplies
   2. Cooling water, purified water
   3. Compressed air, natural gas, other gases
   4. Space and weight factors
   5. Auxiliary equipment or facilities (e.g., dark rooms)

D. Environmental factors
   1. General characteristics (e.g., laboratory, factory, field use)
   2. Temperature, normal and extreme
   3. Humidity, normal and extreme
   4. Dust, dirt, grease, etc.
   5. Vibration, noise
   6. Lighting
   7. Electromagnetic interference

E. Operator requirements
   1. Technical understanding of measurement process
   2. Mathematical ability
   3. Mental attention and alertness during operation
   4. Manual dexterity
   5. Specific knowledge of construction of instrument

F. Continuing Service Support
   1. Built-in reliability
   2. Built-in-test capabilities
   3. Calibration and calibration standards support
   4. Maintenance and repair
   5. Spare parts
   6. Instruction manuals and instrument drawings and schematics
   7. Built-in space to store manuals and schematics
   8. Training or self-education of operators and maintenance technicians

J. Conditions of Sale

Many things, aside from equipment specifications and price, must be described in the final purchase order, as outlined in Checklist V.

Packaging requirements and modes of transportation obviously affect each other. Air transportation is fast and improves the chances of the equipment arriving undamaged. Ocean freight requires very complete and secure packaging.

Unless the supplier is well established in the buying country, local transportation arrangements are best made by the buying establishment.

The conditions of sale should provide clarity about the spare parts, operating supplies, accessories, and auxiliary equipment that are to be included as part of the order for the basic instrument.

The conditions of sale should make it clear that the payment for the instrument will not be authorized until all specified manuals, diagrams, and schematics have been delivered. Appropriate installation and operator training agreements must be specified.

The terms of payment should provide for withholding a significant percentage of the total payment until all of the contracted goods and services have been delivered, conditions of sale met, and satisfactory performance of the instrument achieved. The conditions of sale should be explicit about the definition of "satisfactory performance."

For some conditions of sale, a range of options may be acceptable to the buying organization. Such situations should be made clear to the suppliers, and the suppliers should be asked to specify the options they prefer. In other cases, large organizations, such as the U.S. Agency for International Development, may have required conditions of sale, which suppliers must be told are mandatory.

K. Requests for Quotation

"Requests for Quotation" (RFQ's) are prepared by the purchasing staff of the organization and sent to eligible suppliers. In simple situations, issuance of an RFQ may be done by a telephone call to a well-established supplier. In complex situations completion of this step of the procurement process may take many months.

Normally, RFQ's are sent to all eligible suppliers defined in step G above. However, if there are many such suppliers, RFQ's should be sent only to those most likely to get an order.

CHECKLIST V. CONDITIONS OF SALE

1. Delivery time
2. Penalties for late or incomplete delivery
3. Mode of packaging
4. Mode of transportation
5. Payment of transportation costs
6. Responsibility for local delivery to buyer's site
7. Insurance provisions
8. Mode of handling export and import customs clearances and costs
9. Provision of spare parts, operating supplies, accessories, and auxiliary equipment
10. Installation arrangements
11. Operator training
12. Warranties
13. Acceptance criteria
14. Terms and method of payment

The RFQ incorporates the detailed specifications and acceptable conditions of sale developed in steps H and J above. It clearly specifies the items to be purchased and the numbers of each. It includes a statement which clearly outlines the manner in which the responses (quotations or bids) are to be submitted, the time period over which bids will be accepted, how they will be handled, and other appropriate conditions. The nature of the reasonable expectations that a buying organization may have of a supplier receiving an RFQ is suggested by Checklist VI, which is a form that has been used by a major U.S. Governmental Agency. (Note that some of the provisions of this checklist may be inappropriate for other organizations and other countries. This checklist must be modified to be consistent with the relevant laws and with the policies and practices of the organizations involved.) The quotation documents provided by the responding suppliers are usually regarded as substantially binding legal commitments by those suppliers, until any stated expiration dates occur.

L. Bid Evaluation

As bids are received, they should be listed and tabulated to facilitate comparison. All bids should remain confidential. After the close of the specified bidding period, the bids must be evaluated. Questions to be considered include those in Checklist VII. Technical staff members, although typically not involved in the actual purchasing negotiations, should be included in the bid evaluation process.

Some organizations may be compelled by policy to issue the purchase order to the supplier submitting the lowest cost bid that is fully responsive to the RFQ. We recommend that such policies be avoided whenever possible. It is important before issuing the purchase order to balance all relevant factors that exist at that time. Not all of these can necessarily be reflected in the RFQ or in the considerations involved in determining the eligible suppliers. For instance, if negotiations during the bidding process have led to undue strains with a particular supplier, caution is strongly advised. When the purchaser has a tightly controlled budget or currency, a quotation that does not permit any reserve for eventualities may have to be ruled out.

Generally, the result of the bid evaluation process is a decision to issue a purchase order to a winning bidder. Sometimes, a decision may be made to split the order among two or more suppliers. Sometimes no bid is acceptable and another round of RFQ's is necessary. Usually in this situation, changes must be made in the specifications or conditions of sale. Sometimes negotiations must be held with one or more suppliers to clarify the bids or to obtain agreement on mandatory conditions of sale, before a decision can be made. In such circumstances, the intending seller will be amenable to compromise on his conditions, but such negotiations may have to be conducted without favor or prejudice to any potential seller.

CHECKLIST VI. CHECKLIST FOR THE BIDDER

THE BID YOU SIGN MAY BECOME A BINDING CONTRACT!

Please check the following important points before signing your bid*

DELIVERIES

Can you fulfill the promised schedules?

Have you considered lead time for all raw materials and purchased parts?

Have you read the Default Clause of the General Provisions?

PRICES

Have you checked your computations?

Do you realize that you cannot withdraw or change prices after bids are opened?

SPECIFICATIONS

Do the items offered meet ALL specifications and specification requirements?

Have you listed any differences?

Do you have the current required drawings and specifications?

INSPECTION REQUIREMENTS

Have you provided for necessary test equipment?

Have you planned for a good inspection system?

Have you furnished the required inspection information in your bid?

PACKAGING

Have you read the preservation, packaging, packing and marking specifications?

Have you adequate facilities to comply with packaging specifications?

Have you made commitments to obtain adequate facilities?

POSTAGE

Have you placed sufficient postage on the bid envelope?

Do you realize that it cannot be accepted if there is "POSTAGE DUE"?

Do you realized that bids received late because of return postage cannot be considered?

BID REPLY

Have you signed the original and duplicate copies of your bid?

Are you aware that the envelope enclosed is to be used for returning your bid?

Have you addressed the "Unsuccessful Bidder" postal card and enclosed it with your bid?

NO BID

If you do not intend to bid, have you followed the pertinent instructions contained in the Terms and Conditions of the Invitation for Bid?

*This form is forwarded for your use in ascertaining compliance with good business procedures in submitting a bid on a Government contract. It should not be returned with your bid but is to be used for your own convenience.

All bidders must be notified at the earliest possible date about whether or not their bid is being accepted. Quotations often will include expiration dates, and it is important for the buying organization to be aware of these and act accordingly.

When a choice is made to select a supplier that is not the lowest responsive bidder, the purchasing agent must be able to justify his selection on the basis of objective qualifications and his governing regulations. Particular attention must be paid to following regulations designed to prevent collusion between purchasing agents and vendors.

N. Purchase Order

The winning bidder is notified of his success and informed that a purchase order is being prepared. The purchase order is normally a legal contract that, when accepted by both parties, defines the mutual obligations of buyer and seller. Any details that could become technical, financial, or legal points of dispute must be clearly specified in the purchasing documents.

Orders placed to companies in foreign countries are more complicated than domestic ones, and involve extra considerations such as:

1. A check must be made with local customs officials to clarify any necessary regulations or restrictions that must be included in the order under delivery terms.

2. An approved pro forma invoice should be included to verify the value of the shipment, expedite customs clearance later, and generally avoid future misunderstandings. This pro forma invoice is originated by the selected supplier for approval by the buying organization.

3. Accompanying the order must be a letter of credit, which is from a local bank and includes the exact monetary value of the goods and a confirmation by a bank in the country in which the order is placed.

P. In-House Fabrication

When equipment is to be fabricated in-house, the steps defined above may be somewhat modified. At step C (functional specifications), it is appropriate to diagram the entire proposed apparatus for discussion with the supervisors, designers, and craftsmen in the establishment's workshops. These discussions take place during steps F and G (identification and evaluation of potential suppliers).

The actual decision in favor of internal fabrication may be made without ever requesting quotations from external suppliers. Sometimes it may be appropriate to obtain formal quotations from both internal and external suppliers. In other cases, the decision may be made only after evaluation of the quotations received from the external suppliers.

CHECKLIST VII. BID EVALUATION

1. Are the specifications identical on all bids submitted?
2. Do all suppliers comprehend the performance requirements?
3. Are the specifications cited accurate and complete?
4. How eager are the bidders for the business?
5. Have former dealings with the vendors been satisfactory?
6. How long have the suppliers been in business?
7. What presence do the suppliers maintain in the importing country?
8. Is the distance from the suppliers important?
9. Do all suppliers have technically qualified personnel?
10. Are the delivery times adequate?
11. Are the conditions of sale satisfactory and equivalent?
12. Are the suppliers' arrangements for follow-up service and support adequate?

When the decision has been made to build the equipment in-house, and the design approach has been agreed upon, detailed specifications and working drawings must be prepared. If there is a possibility that a similar apparatus will be constructed in the future or by some other organization, these specifications and drawings must be very complete. Otherwise, they need be adequate only to ensure that the in-house workshop people know exactly what they are expected to build. Cost and delivery time estimates should be obtained. After the proposed construction has been formally approved by higher management and fiscal authorities, the construction order can be placed. Construction should be monitored frequently while in process. Uncertainties in specifications should be clarified and errors corrected. Additional corrections or adjustments should be made during a final check-out process, before accepting delivery of the apparatus.

A combination of in-house fabrication and external procurement may be used in some cases. Care must be taken to ensure the compatibility of the components from the different sources. It may be necessary to delay some of the in-house fabrication activities until purchased units have been delivered.

Q. Follow-up on Purchase Order

No matter how thoroughly the previous steps have been implemented or how well the purchase order written, it still must be assumed that some significant problems will arise before the equipment is delivered and operating. It is essential to maintain communications between buyer and seller throughout the period after issuance of order and before delivery, so that any problems that may arise can be identified and expeditiously resolved.

S. Formal Acceptance of Equipment

The procurement action cannot be considered complete until the equipment has been delivered and installed at the buyer's site, operators have been trained, and initial satisfactory operation has been achieved. All aspects of the total procurement transaction and the performance of the instrument must be carefully reviewed before formal acceptance of the instrumentation occurs and authorization is given for final payment to the seller.

T. Post-Sale Relations

Completion of the procurement action does not end the relationship between buyer and seller. The seller will be regarded by the buyer as a source of operating supplies and spare parts, of training new operators, and of new accessories or retrofitting equipments as they become available. The buyer will be a continuing source of business for the seller, and hopefully a source of recommendations to new potential buyers. Good post-sale relationships benefit both buyer and seller.

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Guidelines are presented for specification and procurement of measurement instrumentation, for use by establishments in developing countries. They were developed in conjunction with a short course on this subject, presented in 1976 to a group of measurement experts from developing countries, by the Denver Research Institute of the University of Denver, Denver, Colorado, USA, under contract from the National Bureau of Standards, with funding from the Agency for International Development. Topics covered include trends in instrumentation, responsibilities of technical and purchasing staff members, motivation for purchase and specific purposes or goals, development of functional specifications, search for and evaluation of suppliers and candidate instruments, development of detailed specifications, identification of conditions of sale, issuance of requests for quotation and evaluation of bids, purchase order issuance and follow-up, formal acceptance of purchased equipment, and post-sale relations with seller.

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